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SEA NYMPH PILOT LCC MODEL DEVELOPMENT REPORT. (U)
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SEA NYMPH Pilot LCC Model Development Report

(14) NUSC-TD-5699

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Newport, Rhode Island • New London, Connecticut

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PREFACE

This report was prepared under Project No. A-55-022, "Integrated Logistic Support Planning for Project Sea Nymph," Sponsoring Activity, Naval Electronic Systems Command Headquarters (Code PME-107-1).

John B. Anderson is a senior electronics engineer associated with RCA Services Company, Waterford, CT.

The authors are grateful for assistance from the following individuals:

Richard Dress, Al Atay, Ottar Rohrstaff of Naval Weapons Engineering Support Activity, Washington Naval Shipyard, Washington, DC.

Eugene Calnan of General Research Corporation, SWL Division, McLean, VA.

REVIEWED AND APPROVED: 15 September 1977

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INTRODUCTION

Effective cost management of the Sea Nymph Project requires a dynamic means to (1) identify, (2) define, (3) estimate, (4) calculate, (5) record, (6) evaluate, (7) control, and (8) update cost data. Such data must be processed automatically because of the large number of cost categories (and the factors they consist of) and the necessity to accurately evaluate their effects during project management decision making.

Upon assessment of available and feasible cost information, it has been determined by the Naval Electronics Systems Command Headquarters (NAVELEX) PME 107-1 that the most suitable automatic data processing alternative is the life cycle cost (LCC) method and computer resources. These were developed for the Chief of Naval Material (CNM) by the Naval Weapons Engineering Support Activity (NAVWPNENGSUPPACT). A description of the basic method to be used is contained in Life Cycle Cost Guide for Equipment Analysis, January 1977, prepared for the Naval Material Command by NAVWPNENGSUPPACT, Management Engineering Department, Cost Management Division. This report documents LCC application to the Sea Nymph Project and explains practical problems that must be addressed in a typical LCC application.

ORGANIZATION

The principal responsibility for achieving cost information management for the duration of the Sea Nymph Project is assigned to NAVELEX PME 107-11. Engineering assistance is to be provided by organizations that are knowledgeable concerning technical factors affecting project costs. The task of applying the LCC method to the unique needs of the Sea Nymph Project was assigned to the Naval Underwater Systems Center (NUSC). The task of maintaining and updating the LCC Model through the equipment's life cycle will be assigned to NAVWPNENGSUPPACT. Figure 1 shows the planned organizational relationships.

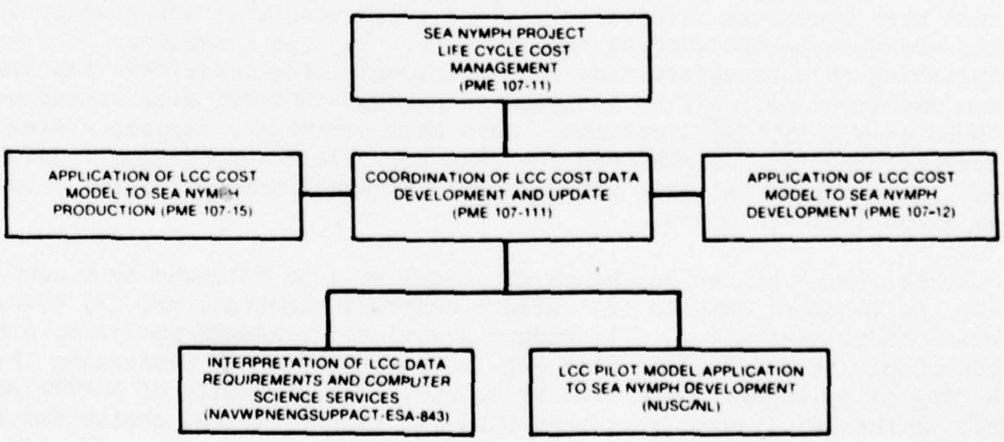

Figure 1. Functional Organization Chart

IMPLEMENTATION

It is recognized that the LCC model for an equipment is a reflection of the stage of the life cycle that the equipment happens to be in. In the early stages, when operating data have not been accumulated, financial data will be characterized by a degree of uncertainty that will, eventually, diminish. Until actual cost information becomes available, data from similar equipments must be used. This means that the usefulness of the LCC model as an accounting tool is limited, but will gradually increase as specific project data are introduced.

The early LCC model is significant, however, in the logistic support planning area. The use of substitute data is not a serious problem when the intention is to evaluate relative costs of various support system options, such as where to store spare parts and whether to invest in a portable circuit card screener at the intermediate level of maintenance. For tradeoff analyses of this type, relative costs of various options are the primary concern and not the accuracy of the bottom-line value. Thus, the construction of an LCC model during the early stages of the life cycle of the equipment is a direct aid to effective logistic support analysis. The injection of actual data (as the program advances) will enhance the tradeoff studies and improve the LCC model's usefulness as an accounting tool.

Implementation of the LCC for Sea Nymph has been based on the assumption that the model will follow the evolution described above. The task of developing a pilot LCC model has been assigned to NUSC, which will apply expertise gained in the AN/BRD-7 program to generate cost factor data for the pilot model. This model will be oriented toward logistic analysis and provide the timely application required if tradeoff analyses are to be accomplished to influence the Sea Nymph support system development.

Completed negotiations for the Limited Projection contract will begin to provide hard data needed for generating forecasts of actual bottom-line LCCs. Data will come from estimates generated by the contractor in response to LCC tasks incorporated into the statements of work. Some of these costs will be the direct result of the tradeoff analyses to be done on the pilot LCC model. The availability of these data will allow the transformation of the logistics oriented pilot LCC model into a management-oriented model. At the same time, new cost work breakdown structures will be introduced to track project office budgets and maintenance funding forecasts for the Type Commander. The task of accomplishing this transformation and constructing the additional Sea Nymph program modifications will be assigned to NAVWPNENGSUPPACT with assistance from NUSC on specific applications. This will permit the support system engineering expertise of NUSC and the computer science expertise of NAVWPNENGSUPPACT to create a realistic LCC product. Figure 2 summarizes the milestones in Sea Nymph implementation.

Establishment of the Sea Nymph LCC model will be followed by a continuing need to update input data to (1) reflect contract negotiations, (2) change projected budget estimates, (3) conduct additional tradeoff analyses, and (4) provide reports for use by NAVELEX PME 107-1 management in presenting the Sea Nymph Program to higher adminstrative levels. The proximity of NAVWPNENGSUPPACT to PME 107-1 identifies that activity as the logical choice for long term support of the LCC model.

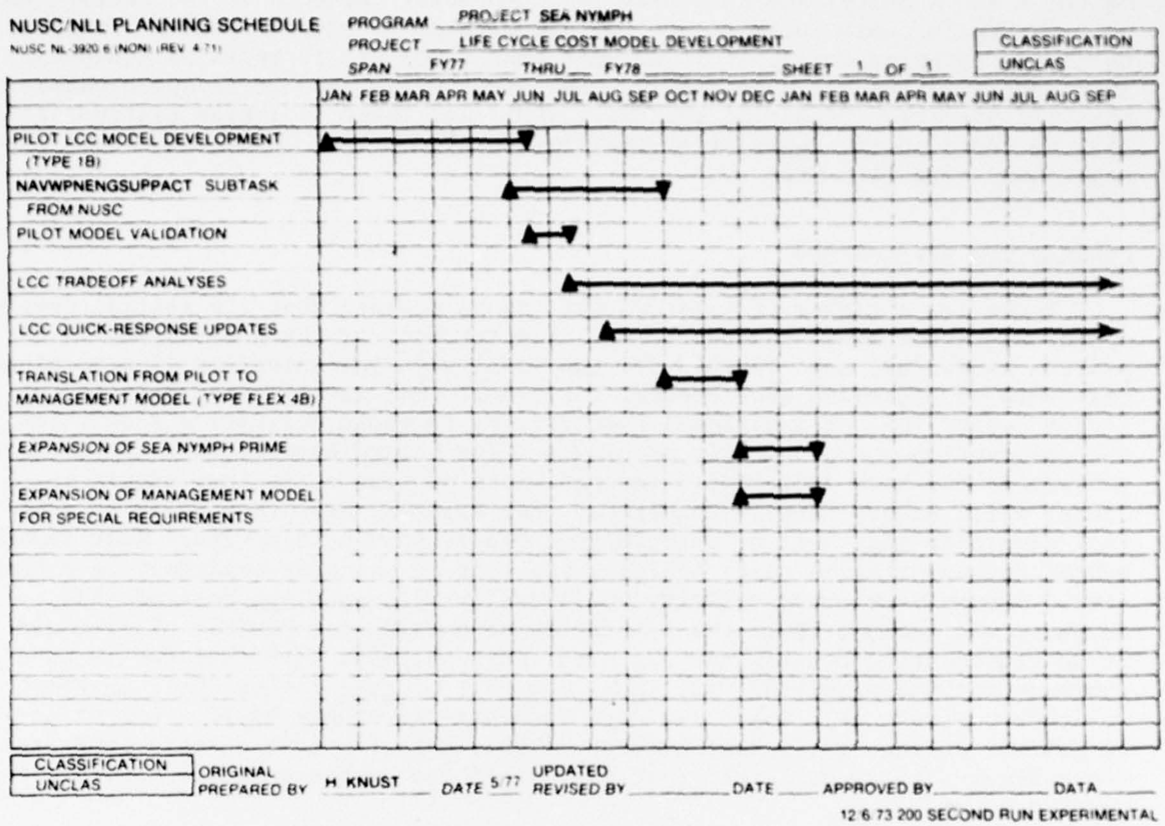

Figure 2. Sea Nymph Milestones

PILOT MODEL PLANNING

DEFINITION OF SEA NYMPH PRIME

One of the first tasks that must be addressed in developing an LCC model is to establish its configuration. Although this is a simple task on most projects, it is a complex problem for Sea Nymph because it is a federated system containing new and old Government furnished equipment (GFE), as well as the E and N Suites. The model could include the AN/BRD-7, which is a separately developed and funded equipment and the AN/UYK-20 Computer, which was developed under the cognizance of NAVELEX (Code 570). It could also include equipment being manufactured by ESL, Inc., that has not been sufficiently developed to provide LCC data.

The orthodox interpretation of the presence of these equipments in the Sea Nymph System would clearly be that their development costs should also be considered. This consideration, however, is beyond the intent of PME 107-1, which is solely interested in those costs directly associated with Sea Nymph. It has been determined, therefore, that for the purpose of the pilot LCC model, the equipments to be identified in the development of cost input factors will

be the E and N Suites and AN/UYK-20 (which present the bulk of the cost). The only AN/UYK-20 costs included are for procurement of the equipment. In order to derive shipping costs, it is assumed that there are 10 racks of equipment. This configuration has been labeled "Sea Nymph Prime" and it is anticipated that the precision measuring equipment (PME) and fault isolation systems (FIS) will be added to the model after the limited production contract has been negotiated with ESL, Inc.

CENTRALIZED DEVELOPMENT

There are a number of hazards that can be avoided when the initial development of an LCC model is undertaken. The tendency of the uninitiated is to address individual cost factors for the model with the intention of combining them into an aggregate that becomes the model. One way of doing this is to assign derivations of individual cost factors to those activities from which the information would normally originate. The hazard here is that two or more activities may have different interpretations of what costs they should include, which causes "double-counting." For example, Sea Nymph will use a 14 rack simulator that will be shipped from Denver to Mountain View. Cost factor BED(E) (transportation cost) includes the cost of shipping equipment to a test site. A supply-oriented activity could easily calculate the cost of this shipment and include it in the generation of a value for BED(E). This would be double-counting because the costs for this shipment were included in the contract for the simulator and, thus, are part of cost factor DS(I) (payment to other contractors), which includes payments* to others besides the prime contractor during development efforts. Thus, data for this example come from two sources with no certainty that they would coordinate on their own initiative.

A second hazard to be dealt with is the ripple effect that results when a key cost factor is changed; i.e., other factors must then change. For instance, if cost factor PTM (personnel receiving training) is changed, it causes BTS (student travel cost) to change and if different activities are preparing values, the PTM might be based on one assumption and the BTS on another.

The logical means to avoid ripple effects and double-counting is to centralize the development of cost factors and impose a type of configuration control. It is essential that there be a clear understanding of exactly what has been included and excluded in the derivation of each cost factor. This has led to the establishment of cost factor analysis reports, which are being maintained at NUSC and NAVELEX PME 107-1. A sample of such a report and an abbreviated summary sheet including all input data are presented in appendix A.

CONTRACTOR DATA INPUTS

A significant number of LCC input factors must originate with the contractor, who in this case will be GTE, Sylvania, for the Sea Nymph Prime and, eventually, ESL, Inc., for the PME and FIS subsystems. Sylvania has proposed construction of a Sea Nymph LCC model using Navy programs on their IBM 370

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*In this case to the Martin Marietta, Co.

computer. This approach, however, is inappropriate because sensitive program office information that would compromise the Government's contractual negotiating position would have to be used. It would also be inappropriate to provide the contractor with data inputs generated within the Navy because assumptions made in deriving estimated charges for such items as cost factor DT (i.e., the contractor's charge for factory training) might compromise a contractual negotiating position.

The above discussion does not mean that the contractor has no valid role to play in the development of an effective LCC model. There are several dozen cost factors, from the cost of text books to the assignment of factory floor space for depot repairs, that are needed. Many specific costs are not available from existing contracts because negotiations often result in payment of a lump sum for spare parts, engineering services, etc; therefore, the specific amount for a particular item is not identified. There is a resulting need to generate a unique data item for cost factor inputs from the contractor. This will guide the contractor in providing meaningful inputs that can be incorporated directly into the LCC model. A proposed data item description is presented in figure 3.

PILOT MODEL APPLICATION

It is intended that the pilot LCC model for Sea Nymph be used to evaluate the relative costs of a number of alternative support approaches. Some of these tradeoffs have been identified and will influence the contents of production contracts; others will be identified as the system evolves. It is correct to envision the Field Maintenance Agent (FMA) using a future iteration of the LCC model to determine which of several alternatives will provide the most cost-effective solution to a support problem on production equipment installed in the Fleet. A list of the tradeoff studies planned as an initial effort is provided in appendix B.

TRANSLATION FROM IB TO FLEX 4B COMPUTER PROGRAM

The LCC pilot model currently being developed is a logistic oriented program employing the IB Computer Program prepared by NAVWPNENGSUPPACT. This program is sufficient to meet an immediate need for analysis concurrent with the contractor's logistic support analysis (LSA) efforts. The options for support system design that develop from the LSA will be employed in the LCC pilot model. The results will then be used to arrive at fundamental decisions concerning the support system structure.

However, there are some limitations using the IB Computer Program that make it desireable to transfer to the FLEX 4B Computer Program (also developed by NAVWPENENGSUPPACT) when possible. The FLEX 4B Program will allow the incorporation of management accounting needs, such as a separate budgeting profile for each of the branches of PME 107-1 and funding projections for external Naval Activities that will be supporting Sea Nymph in the Fleet.

DATA ITEM DESCRIPTION

1. TITLE DATA, LOGISTIC, FOR LIFE CYCLE COST PLANNING	2. IDENTIFICATION NO(S). AGENCY: NAVY-EC NUMBER: UDI-L-223XX
3. DESCRIPTION/PURPOSE THESE DATA DEFINE AND QUANTIFY PROJECT COSTS ASSOCIATED WITH THE ELEMENTS OF INTEGRATED LOGISTIC SUPPORT (ILS).	4. APPROVAL DATE 5. OFFICE OF PRIMARY RESPONSIBILITY PME 107 6. DDC REQUIRED 8. APPROVAL LIMITATION
7. APPLICATION/INTERRELATIONSHIP THESE DATA PROVIDE COST FACTOR INPUTS TO LIFE CYCLE COST (LCC) MODELS FOR ADVANCED PROGRAM SUPPORT PLANNING.	9. REFERENCES (Mandatory as cited in block 10) NAVWPNENGSUPPACT LIFE CYCLE COST GUIDE FOR EQUIPMENT ANALYSIS JANUARY 1977 MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

10.1 UNLESS OTHERWISE SPECIFIED IN THE INVITATION FOR BIDS OR REQUEST FOR PROPOSALS, THE DOCUMENTS CITED IN THIS BLOCK (OF THE ISSUE IN EFFECT ON THE DATE OF SUCH INVITATION OR REQUEST) FORM A PART OF THIS DATA ITEM DESCRIPTION (DID) TO THE EXTENT SPECIFIED.

10.2 THESE DATA ARE PREPARED BY THE CONTRACTOR IN HIS OWN FORMAT AND CONTAIN THE NEGOTIATED PRICE ASSOCIATED WITH THE CONTRACT STATEMENT OF WORK IN TERMS OF THE LIFE CYCLE COST FACTOR DEFINITIONS OF NAVWPNENGSUPPACT LCC GUIDE (JANUARY 77). THESE COSTS ARE PROJECTED IN TERMS OF GOVERNMENT FISCAL YEARS.

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Figure 3. Proposed Data Item Description

EXPANSION OF SEA NYMPH PRIME

Sea Nymph Prime was defined in this document as consisting of the E and N Suites and associated AN/UYK-20 Computers. There will be a need to expand this configuration to include AN/USH-24 Wideband Tape Recorders, PME and FIS subsystems, and other "carry-on" equipment. Management at PME 107-1 will determine necessary additional equipment and the scope of the additions on a case basis. For instance, the AN/UYK-20 is part of Sea Nymph Prime but the scope is currently limited to the cost of the machines. Training on the AN/UYK-20 is not addressed, except as part of the E and N Suites factory training. Additional "stand-alone" training may be required. The decision as to whether this is a Sea Nymph cost or one to be shared with other Projects and Commands is the responsibility of NAVELEX PME 107-1.

PILOT MODEL DEVELOPMENT

DERIVATION OF COST FACTORS

There are 98 cost factors associated with the LCC Model 1B program (see figure 4) used for the Sea Nymph Pilot Model. The factors are divided into the four basic cost categories of (1) development, (2) acquisition, (3) initial nonrecurring, and (4) recurring. The 98 cost factors are grouped by category in figure 5.

The derivation effort is also organized in terms of four cost factor categories. Specific factors in each category are screened to determine those that have great bearing on the derivation of others. This may take the form of similar background research or it may be that one factor is undefinable until another has been established. The result of the screening is a plan for a sequence of investigations that will build the life cycle cost model efficiently.

It is important to remember that the interpretation of the definition of a cost factor plays a significant role in properly directing the course of the background work. It is insufficient to understand only the definitions of the words used because the application of a factor in the algorithms may change the meaning. For example, travel costs may be interpreted to mean round-trip fares, but the algorithm in the Model 1B LCC multiplies fares by two; therefore, one-way values must be used initially.

DEVELOPMENT COSTS

Samples of cost breakdown structures and associated cost factors are shown in figure 6. Many of the factors in this category hinge on the derivation of BEP(P), which is the travel cost associated with the training for test and evaluation (T&E). To derive BEP(P), it is necessary to know the following information (which also applies to other cost factor derivations):

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LIFE CYCLE COST ANALYSIS
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DATE 7/19/77
PAGE 3.001

NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

DESCRIPTION OF VARIABLES

NAME	NO.	UNITS	DESCRIPTION
BFD(E)	1CBFD	$/ITEM	COST OF TRANSPORTING SPECIFIC EQUIPMENT FROM CONTRACTOR FACILITY TO TEST SITE
BFO	4FBFO	$/SYSTEM	COST OF TRANSPORTING SYSTEM FROM CONTRACTOR FACILITY TO POINT OF INSTALLATION
BFP(P)	1CBFP	$	ONE-WAY TRANSP. COST FOR PERSONNEL BETWEEN TRNG SITE OR HOME STATION AND TEST SITE
BTS	3EBTS	$/PERSON	STUDENT TRAVEL COST FOR INITIAL TRAINING COURSE
BY	1ABY	DIMENSIONLESS	FIRST ITH YEAR DURING WHICH INFLATION-DISCOUNTING OF COSTS WILL OCCUR
CSFAF	4ICSFAF	$/SQ.FT./YR	ANNUAL COST STANDARD FOR O/I MAINTENANCE SPACE
CSFAS	4ICSFAS	$/SQ.FT./YR	ANNUAL COST STANDARD FOR DEPOT LEVEL MAINTENANCE SPACE
CU	2DCU	$/SYSTEM	UNIT PRICE OF ONE OF THE CONTRACTORS SYSTEMS
DB	4FDB	$/PERSON	COST OF STUDENT TEXTS, LEARNING GUIDES AND MANUALS SUPPLIED BY THE CONTRACTOR
DC(I)	1ADC	$	PAYMENT BY GOVERNMENT TO PRIME CONTRACTOR FOR DEVELOPMENT EFFORT DURING YEAR I
DD	3GDD	$	ACQUISITION COST OF DATA IF NOT INCLUDED IN ACQUISITION COST OF SYSTEM
DDD(S)	1CDDD	$	DISMANTLING COSTS INCURRED BY THE GOVERNMENT FOR EQUIPMENT AND MATERIAL REMOVED FROM TEST SITE
DDI(S)	1CDDI	$	INSTALLATION COSTS INCURRED BY GOV. FOR INSTALLATION OF PROTOTYPE(S) ON DESIGNATED TEST SITE
DDM(K)	4JDDM	$/ITEM	DEPOT MATERIAL COST STANDARD
DIM	4DDIM	$/SYSTEM	COST OF INSTALLATION NOT COVERED BY ACQUISITION COST
DIS	3FDIS	$	ACQUISITION COST OF INITIAL SPARES IF THEY ARE NOT INCLUDED IN SYSTEM ACQUISITION COST
DM(S)	1CDM	$/SITE	MODIFICATION COSTS INCURRED BY THE GVT. AT A TEST SITE DURING INSTALLATION OF PROTOTYPE SYSTEM
DR	1ADR	RATIO	ANNUAL DISCOUNT RATE FOR FUTURE COSTS
DS(I)	1BDS	$	PAYMENT BY GOVERNMENT TO OTHER CONTRACTORS FOR DEVELOPMENT EFFORT DURING YEAR I
DSM	4JDSM	$/ITEM	AVERAGE MATERIAL COST STANDARD FOR O/I MAINTENANCE
DSP(I)	4FDSP	$	COST OF SPARES TO KEEP SYSTEMS IN OPERATION AND MAINTAIN APPROPRIATE PIPELINE OF REPARABLES
DT	3EDT	$/PERSON	CONTRACTORS CHARGE FOR STUDENT TRAINING DURING THE INITIAL TRAINING PROGRAM
DTE(I)	4HDTE	$	COST OF SPECIAL TEST EQUIPMENT
DTES(I)	1CDTES	DIMENSIONLESS	YEARLY COST ALLOCATION FACTOR FOR DEVELOPMENT TESTING AND EVALUATION PROGRAM
DTG	4FDTG	$/MANWEEK	COST TO GOVERNMENT FOR CONDUCTING RECURRING TRAINING COURSES, EXCLUDING THE STUDENT COSTS
DTI	3FDTI	$/LOCATION	INSTALLATION COST OF TRAINING EQUIPMENT AND MATERIAL
DTS(I)	1FDTS	DIMENSIONLESS	YEARLY COST ALLOCATION FACTOR FOR DEVELOPMENT TEST AND EVALUATION TRAINING PROGRAM
DTU	3FDTU	$/LOCATION	ACQUISITION COST OF SYSTEM TRAINING AIDS
E			DESIGNATOR FOR SPECIFIC EQUIPMENT - VARIES FROM 1 TO NCE
F			DESIGNATOR FOR SPECIFIC GOVERNMENT FACILITY - VARIES FROM 1 TO NTFD
G			DESIGNATOR FOR SPECIFIC GRADE OF CIVILIAN - VARIES FROM 1 TO NDOC
I			DESIGNATOR FOR SPECIFIC PROJECT YEAR - VARIES FROM 1 TO Y
IR	1AIR	DIMENSIONLESS	ANNUAL INFLATION RATE FOR COSTS
ISAF(I)	4JISAF	SQ.FT./YEAR	MAINTENANCE STORAGE SPACE REQUIRED FOR THE O/I INVENTORY DURING YEAR I
ISAS(I)	4JISAS	SQ.FT./YEAR	MAINTENANCE STORAGE SPACE REQUIRED FOR THE DEPOT INVENTORY DURING YEAR I
IYI	1AIYI	DIMENSIONLESS	YEAR I DURING WHICH THE INITIAL/NON-RECURRING COSTS OCCUR
K			DESIGNATOR FOR SPECIFIC SPARE/REPAIR ITEM - VARIES FROM 1 TO NK
LDR(K)	4JLDR	HOURS/ITEM	DEPOT LABOR TIME STANDARD TO REPAIR
LM(I)	4FLM	PERSONS/YEAR	DESIRED MANNING LEVEL FOR ORM SKILLED MAINTENANCE PERSONNEL
LP(I)	4FLP	PERSONS/YEAR	DESIRED MANNING LEVEL FOR PROFESSIONAL SKILLED MAINTENANCE PERSONNEL
LPM(K)	4JLPM	HOURS/ITEM	ORGANIZATIONAL LEVEL LABOR TIME STANDARD FOR PREVENTIVE MAINTENANCE
LSD(K)	4JLSD	HOURS/ITEM	ORGANIZATIONAL LEVEL LABOR TIME STANDARD TO DETECT, ISOLATE, REMOVE AND REPLACE
LSR(K)	4JLSR	HOURS/ITEM	INTERMEDIATE MAINTENANCE LEVEL LABOR TIME STANDARD TO REPAIR
MSAF(I)	4JMSAF	SQ.FT./YEAR	SPACE REQUIRED FOR O/I MAINTENANCE SHOPS DURING YEAR I
MSAS(I)	4JMSAS	SQ.FT./YEAR	SPACE REQUIRED FOR DEPOT MAINTENANCE SHOPS DURING YEAR I

Figure 4. Cost Factors Associated with LCC 1B Program

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LIFE CYCLE COST ANALYSIS
MOD 1-B

DATE 7/19/77
PAGE 3.002

NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

DESCRIPTION OF VARIABLES

NAME	NO.	UNITS	DESCRIPTION
N(I)	4IN	SYSTEMS	NUMBER OF SYSTEMS IN INVENTORY AT END OF YEAR I
NC	3GNC	COPIES	NUMBER OF COPIES OF TECHNICAL DATA TO BE DISTRIBUTED AND INVENTORIED
NCF	1CNCF	DIMENSIONLESS	TOTAL NUMBER OF EQUIPMENTS & MATERIAL TRANSPORTED FROM CONTRACTORS FACILITY TO PT OF INSTALL
ND	3GND	PAGES	AVERAGE NUMBER OF PAGES PER TECHNICAL MANUAL MAINTAINED BY NAVY
NDOC	1CNDOC	DIMENSIONLESS	TOTAL NUMBER OF CIVILIAN GRADES REQUIRED FOR THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
NDOM	1CNDOM	DIMENSIONLESS	TOTAL NUMBER OF MILITARY RANKS REQUIRED FOR THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
NDP	1CNDP	DIMENSIONLESS	NUMBER OF GOV. PERSONNEL REQUIRED FOR SITE TESTING OF CONTRACTORS SYSTEM
NH(K)	4JNH	HOURS	EXPECTED HOURS THAT KTH ITEM WILL BE USED PER YEAR
NK	4JNK	DIMENSIONLESS	NUMBER OF REPARABLE ITEMS IN THE SYSTEMS
NN(I)	2ONN	SYSTEMS	NUMBER OF SYSTEMS ACQUIRED DURING THE ITH YEAR
NNT	3ENNI	FSN	TOTAL NUMBER OF NEW FSNS TO BE ISSUED ON THE SYSTEM
NPM(K)	4JNPM	HOURS/ACTION	AVERAGE TIME BETWEEN PREVENTIVE MAINTENANCE ACTIONS FOR ITEM K
NS	1CNS	DIMENSIONLESS	TOTAL NUMBER OF TEST SITES USED DURING THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
NTEN	3ENTEN	FSN	NUMBER OF NEW FSNS REQUIRED FOR SPECIAL TEST EQUIPMENT FOR SERVICING SYSTEM
NTFD	1ENTFD	DIMENSIONLESS	TOTAL NUMBER OF GVT. FACILITIES REQUIRED DURING DEVELOPMENT PHASE MAINTENANCE TRAINING PROGRAM
NTU	3ENTU	LOCATIONS	NUMBER OF LOCATIONS WHICH PROVIDE TRAINING IN MAINTENANCE AND OPERATION OF SYSTEM
P			DESIGNATOR FOR SPECIFIC GOVERNMENT PERSON - VARIES FROM 1 TO NDP
PC(G)	1CPC	PERSONS	NUMBER OF CIVILIAN PERSONNEL OF GRADE G REQUIRED DURING DEV. PHASE TEST AND EVAL. MAINT PROGRAM
PM(R)	1CPM	PERSONS	NUMBER OF MILITARY PERSONNEL OF RANK R REQUIRED DURING DEV. PHASE TEST AND EVAL. MAINT. PROGRAM
PO	4TPO	PERSONS/SYSTEMS	NUMBER OF OPERATING PERSONNEL REQUIRED PER SYSTEM
PSOS	4IPSOS	SQ.FT./SYSTEM	FLOOR SPACE REQUIRED FOR THE OPERATION OF PRIME SYSTEM
PTM	3EPTM	PERSONS/YR	NUMBER OF O&M SKILLED MAINTENANCE PERSONNEL TO RECEIVE INITIAL TRAINING
PTP	3EPTP	PERSONS/YR	NUMBER OF PROFESSIONAL SKILLED MAINTENANCE PERSONNEL TO RECEIVE INITIAL TRAINING
R			DESIGNATOR FOR SPECIFIC MILITARY RANK - VARIES FROM 1 TO NDOM
R(K)	4JR	HOURS/FAILURE	MEAN TIME BETWEEN FAILURES FOR ITEM K
RAM	4ERAM	RATIO	TURNOVER RATE FOR O&M SKILLED MAINTENANCE PERSONNEL
RAP	4ERAP	RATIO	TURNOVER RATE FOR PROFESSIONAL SKILLED MAINTENANCE PERSONNEL
RC(G)	1CRC	$/MANDAY	DAILY COST RATE FOR CIVILIAN PERSONNEL OF GRADE G
RDL	4JRDL	$/MAN/HOUR	AVERAGE DEPOT LABOR RATE TO REPAIR FAILED ITEMS
RF(F)	1FRF	$/FACILITY DAY	DAILY COST RATE FOR GOVERNMENT FACILITY
RFM	3GRFM	$/PAGE/YR	ANNUAL COST PER PAGE OF TECHNICAL DATA FOR FILE MAINTENANCE
RIE	3ERIE	$/FSN	ITEM ENTRY COST INTO THE FEDERAL STOCK SYSTEM
RIM	4ERIM	$/FSN/YR	ANNUAL ITEM RETENTION COST IN THE FEDERAL STOCK SYSTEM
RM(R)	1CRM	$/MANDAY	DAILY COST RATE FOR MILITARY PERSONNEL OF LEVEL R
RO	4TRO	$/MAN/YR	AVERAGE ANNUAL COST FOR SYSTEM OPERATIONS PERSONNEL
RP	3GRP	$/PAGECOPY	COST PER PAGE FOR INITIAL REPRODUCTION AND DISTRIBUTION OF TECHNICAL DATA
RPL	4JRPL	$/POUND	STANDARD PACKING LABOR RATE
RPM	4JRPM	$/POUND	STANDARD PACKING MATERIAL RATE
RSL	4JRSL	$/MAN/HOUR	AVERAGE ORGANIZATION AND INTERMEDIATE MAINTENANCE LABOR RATE TO REPAIR FAILED ITEMS
RSO(S)	1CRSO	$/SITE/DAY	AVERAGE DAILY OPERATING COST FOR NORMAL OPERATIONS OF A TEST SITE
RSR	4JRSR	$/POUND	AVERAGE SHIPPING RATE
RSS(K)	4JRSS	RATIO	FRACTION OF FAILURES REPAIRED AT THE INTERMEDIATE MAINTENANCE LEVEL
RTM	3ERTM	$/MAN/WEEK	AVERAGE WEEKLY STUDENT PAY AND ALLOWANCE RATE DURING THE O&M COURSE
RTP	3FRTP	$/MAN/WEEK	AVERAGE WEEKLY STUDENT PAY AND ALLOWANCE RATE DURING THE PROFESSIONAL MAINTENANCE COURSE
RW(K)	4JRW	DIMENSIONLESS	RATIO OF PACKAGED TO THE UNPACKAGED WEIGHT

Figure 4. (Cont'd) Cost Factors Associated with LCC 1B Program

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LIFE CYCLE COST ANALYSIS
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NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

DESCRIPTION OF VARIABLES

NAME	NO.	UNITS	DESCRIPTION
S			DESIGNATOR FOR SPECIFIC TEST SITE - VARIES FROM 1 TO NS
TDC(S)	1CTDD	DAYS/SITE	NUMBER OF DAYS A TEST SITE IS UTILIZED DURING THE DEVELOPMENT PHASE TEST AND EVALUATION PROGRAM
TTDC	1FTTDC	DAYS/STUDENT	TRAINING DAYS REQUIRED FOR CIVILIAN PERSONNEL DURING THE DEV. PHASE TEST AND EVALUATION PROGRAM
TTDM	1FTTDM	DAYS/STUDENT	TRAINING DAYS REQUIRED FOR MILITARY PERSONNEL DURING THE DEV. PHASE TEST AND EVALUATION PROGRAM
TTFD(F)	1FTTFD	DAYS/LOCATION	NUMBER OF DAYS TRAINING FACILITY F WILL BE REQD. DURING DEV. PHASE TEST AND EVALUATION PROGRAM
TTL	3FTTL	WEEKS/STUDENT	AVERAGE NUMBER OF WEEKS REQUIRED FOR TRAINING PROGRAM
W(K)	4JW	POUNDS/ITEM	UNPACKED WEIGHT OF THE ITEM
Y	1AY	DIMENSIONLESS	THE LAST YEAR DURING WHICH A COST IS INCURRED FOR THIS ANALYSIS

Figure 4. (Cont'd) Cost Factors Associated with LCC 1B Program

FACTORS ASSOCIATED WITH DEVELOPMENT COST

BY	DC(I)	DR	IR	IYI	Y
BED(E)	BEP(P)	DDD(S)	DDI(S)	DM(S)	DTES(I)
NCF	NDOC	NDOM	NDP	NS	PC(G)
PM(R)	RC(G)	RM(R)	RSO(S)	TDO(S)	DS(I)
DTS(I)	NTFD	RF(F)	TTDC	TTDM	TTFD(F)

FACTORS ASSOCIATED WITH ACQUISITION COSTS

CU	NN(I)

FACTORS ASSOCIATED WITH INITIAL/NONRECURRING COSTS

BTS	DTI	NTU	PTP	RTP	DIS
ND	RP	NC	NTEN	DT	DTU
PTM	TRM	TTL	NNI	RFM	DD
RIE					

FACTORS ASSOCIATED WITH RECURRING COSTS

DIM	BOE	DB	DTG	LM(I)	LP(I)
RAM	RAP	DSP(I)	RIM	DTE(I)	CSFAF
CSFAS	N(I)	PO	PSOS	RO	NK
NPM(K)	R(K)	RDL	RPL	RPM	RSL
RSR	RSS(K)	RW(K)	W(K)	DDM(K)	DSM
ISAF(I)	LDR(K)	LPM(K)	LSD(K)	LSR(K)	MSAF(I)
MSAS(I)	NH(K)	ISAS(I)			

DESIGNATORS

E	F	G	I	K	P
R	S				

Figure 5. Cost Factors by Category

WBS	FUNCTION	COST FACTORS INVOLVED
110 000	PAYMENT BY GOVERNMENT TO PRIME CONTRACTOR FOR SYSTEM DEVELOPMENT EFFORT	DC(I)
120 000	PAYMENT BY GOVERNMENT TO OTHER THAN PRIME CONTRACTOR FOR SYSTEM DEVELOPMENT EFFORT	DS(I)
131 110	MILITARY PAY AND ALLOWANCE COSTS DURING MAINTENANCE TRAINING FOR T&E EFFORT	DTS(I) NDOM TTDM PM(R) RM(R)
131 120	CIVILIAN PAY AND ALLOWANCE COSTS DURING MAINTENANCE TRAINING FOR T&E EFFORT	DTS(I) NDOC TTDC PC(G) RC(G)
131 200	GOVERNMENT FACILITY COSTS INCURRED DURING T&E EFFORT	DTS(I) NTFD TTFD RF(F)
132 110	TEST SITE MODIFICATION COSTS INCURRED DURING T&E EFFORT	DTES(I) NS DM(S)
132 120	PROTOTYPE INSTALLATION COSTS AT T&E TEST SITES	DTES(I) NS DDI(S)
132 130	TEST SITE OPERATION COSTS DURING T&E EFFORT	DTES(I) NS TDO(S) RSO(S)
132 140	TEST SITE RESTORATION COSTS AFTER CONCLUSION OF T&E EFFORT	DTES(I) DDD(S)
132 210	MILITARY PAY AND ALLOWANCES INCURRED DURING T&E EFFORT	DTES(I) NDOM NS PM(R) RM(R) TDO(S)
132 220	CIVILIAN PAY AND ALLOWANCES INCURRED DURING T&E EFFORT	DTES(I) NS RC(G) PC(G)
132 300	TRAVEL COSTS INCURRED DURING TRAINING FOR T&E EFFORT	DTES(I) NDP BEP(P)
132 400	TRANSPORTATION OF MATERIAL COSTS FROM CONTRACTOR TO TEST SITE DURING T&E EFFORT	DTES(I) NCF BED(E)

Figure 6. Development Cost Work Breakdown Structures

1. number of training sites,
2. ranks of students and instructors,
3. number of students,
4. number of instructors,
5. course length,
6. car rental fees,
7. plane fares,
8. per diem costs, and
9. number of classes.

When these costs have been defined many other cost factors will also have been because of overlapping and parallel research. Specifically, defining the training sites identifies the following cost factors:

1. S -- the designator for the specific test site and
2. NS -- the total number of test sites during development.*

When defining the number of personnel involved with development T&E (as an input to the BEP(P) derivation) the following cost factors are identified:

1. NDOC -- the pay grades of civilian T&E personnel,
2. NDP -- the number of government personnel involved with site testing and training,
3. PC(G) -- the number of civilians of each pay grade involved with T&E,
4. PM(R) -- the number of military of each rank involved in T&E, and
5. NDOM -- the number of military ranks involved with T&E.

When determining the number and length of training and testing periods for BEP(P), the basic information exists to define the following cost factors:

1. DTS(I) -- the yearly cost allocation by year for T&E training,
2. TTFD(F) -- the number of days the training facility is used during T&E, and
3. TDO(S) -- the number of days the test site is used for T&E.

---

*The initial training and the test site were at the same location for Sea Nymph application.

In a similar fashion, the basic information for the following cost factors are derived in the process of generating the derivation of BEP(P):

1. DTES(I) -- the yearly cost allocation by year for T&E effort,

2. TTDM -- the military training days during T&E

3. NTFD -- the number government facilities required during T&E, and

4. TTDC -- the civilian training days required during T&E.

The family of cost factors associated with BEP(P) leads to the derivation of other cost factors in a logical progression that is illustrated in figure 7. This process can be applied to the three other cost factor categories.

ALGORITHM IMPACT

As was mentioned earlier, it is insufficient to rely on language to determine what a cost factor will be used for because the algorithm may impose additional interpretations or restrictions. Furthermore, it is important to understand how to express the cost factor as input data to the computer software. Two examples of this in the Sea Nymph derivation are

1. PM(R) -- the number of military personnel of rank R required during the development phase of the T&E maintenance program and

2. RM(R) -- the daily cost rate for military personnel of rank R.

These cost factors are used in Cost Breakdown Structure CBS 132 210, for which military personnel pay and allowance costs incurred during the T&E maintenance program are calculated according to the following algorithm:

$$\begin{array}{c}\text{Annual}\\\text{Allocation}\\\text{Factor}\end{array} * \begin{array}{c}\text{Days in}\\\text{Testing}\\\text{Period}\end{array} * \begin{array}{c}\text{Number}\\\text{of}\\\text{Personnel}\end{array} * \begin{array}{c}\text{Daily}\\\text{Pay}\\\text{Rate}\end{array}$$

or

$$\sum_{I=1}^{Y} DTES(I) \sum_{S=1}^{NS} TDO(S) \sum_{R=1}^{NDOM} PM(R) * RM(R) ,$$

where

NDOM = total number of military ranks required for the T&E development phase,

R = designator for specific military rank (form 1 to NDOM)

DTES(I) = yearly cost allocation for T&E development phase, and

TDO(S) = number of days a test site is used during T&E development.

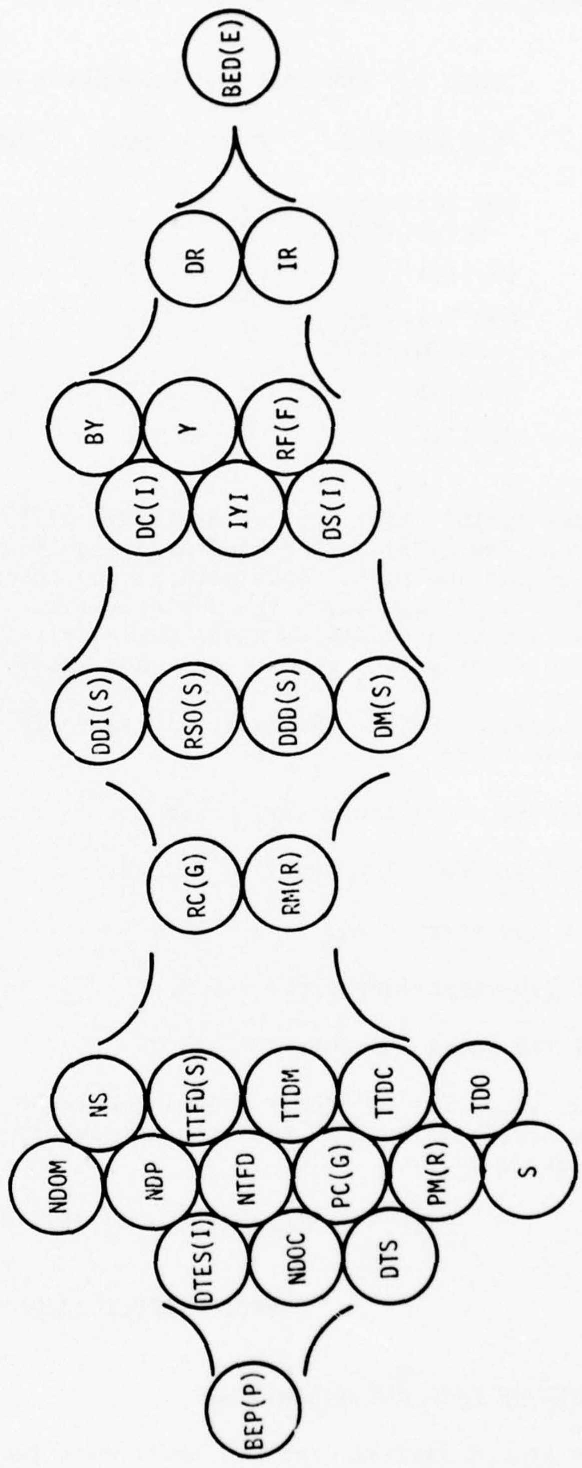

Figure 7. Flow Chart for Derivation of Development Cost Factors

Table 1 shows the number of military personnel involved with the T&E development programs, i.e., a total of 5 ranks, or PM(R) = 5.

Table 1. EDM Test and Evaluation Military Ranks

T&E Program	ET-2	ET-1	ETC	04	05
EDM Training for OT-IIIA	2	2	1	1	1
OT-IIIA	2	2	1	1	1
EDM Training for OT-IIIB	2	2	1	1	1
OT-IIIB	2	2	1	1	1
OT-IIIC	2	2	1	1	1

However, cost factor PM(R) must be expressed differently to satisfy programming requirements. The PM(R) must be factored such that there are two ranks with a population of two and three ranks with a population of one. Thus PM(R) = 5 becomes (2)(2) + (3)(1), where the computer first addresses the ranks having a value of two and then addresses those having a value of one. It should be noted that this software procedure may vary according to the computer used.

In the case of RM(R), the daily pay rates for the five military ranks given in table 1 are:

1. ET-2 (4 years longevity) = $18.61
2. ET-1 (6 years longevity) = $21.85
3. ETC (10 years longevity) = $26.28
4. 05 (10 years longevity) = $50.20
5. 04 (10 years longevity) = $48.26

The original value for RM(R) was calculated to be the mean value of the above rates. However, the input to the computer is expressed in terms of the individual values, i.e.,

RM(R) = 18.61, 21.85, 26.28, 48.26, 50.20

COMPUTER APPLICATION

COMPATIBILITY OF DATA AND ALGORITHMS

As was stated earlier, the LCC model cost factors must reflect the situation for a specific project while remaining compatible with the algorithms of the software program. It is sometimes necessary to restructure

data or use an approximation to acheive compatibility with algorithms that have been structured to fit many projects. As a result, there is a requirement to screen the cost factor derivations that are prepared for compatibility. This may result in an iterative process in which changes to make one derivation compatible may trigger a ripple through other cost factor derivations.

The LCC 1B Computer Software Program has, in its current state, limitations relative to certain allowable magnitudes exceeded during Sea Nymph derivation efforts. Cost factor BEP(P), a subscripted variable, was computed to be $58,041.32 for the one-way transportation costs associated with military and civilian personnel traveling to and from the T&E site. The algorithm (WBS 132 300) in which BEP(P) appears defines this cost factor as

WBS 132 300

$$\sum_{I=1}^{Y} \mathrm{DTES(I)} \sum_{P=1}^{NDP} * 2 * \mathrm{BEP(P)} \ ,$$

where

BEP(P) = one-way travel costs,

NDP = number of personnel, and

DTES(I) = fraction of total costs occurring each year.

The resultant value is then multiplied by two to yield round-trip travel costs for each year.

However, the upper limit for the value of BEP(P) in the 1B Computer Software Program is $9,999.99. The adjustment is accomplished by dividing BEP(P) by 11 to yield 5,276.48, which is within the upper limit. Therefore, when BEP(P) is applied in the software program it becomes (5,267.48)(11) and the costs are summed across the range of NDP, as indicated by the algorithm. This approach permits the computer to perform correctly.

COMPUTATION OF ALGORITHMS

The 98 cost factor values that have been derived are loaded by card deck and used for computation of algorithms associated with the cost breakdown structures. A sample of the computed values is provided in figure 8. A typical computation is CBS 471 100 (cost of maintenance labor), which has the following algorithm:

$$\mathrm{N(I)} \sum_{K=1}^{NK} \mathrm{NH(K)} * \mathrm{LSD(K)} * \mathrm{RSL} \div \mathrm{R(K)} \ ,$$

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NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY, NEW LONDON, CT. (PA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT — SPONSOR-NAVALEX-PME-107

COST BREAKDOWN STRUCTURE REPORT

INFLATION= .0%,DISCOUNT= .0%,BASE YEAR= 1

$$$ COSTS IN THOUSAND DOLLARS $$$

COST BREAKDOWN STRUCTURE NUMBER	COST BREAKDOWN STRUCTURE ELEMENT	TOTAL ADJUSTED COST	<---PERCENTS OF TOTAL ADJUSTED COST---->			
			< FOR TOTAL LIFE CYCLE >			
324000	AIDS	9262.50		1.6		
324100	ACQUISITION	9000.00	1.6			
324200	INSTALLATION	262.50	.0			
330000	SUPPLY SUPPORT	150.00			.0	
331000	ACQUISITION OF INITIAL SPARES	.00		.0		
332000	INTRODUCTION INTO THE SUPPLY SYSTEM	150.00		.0		
332100	NEW FSNS IN PRIME SYSTEM	150.00	.0			
332200	NEW FSNS IN SUPPORT EQUIPMENT	.00	.0			
400000	RECURRING	153821.50				27.2
410000	PRIME SYSTEM	4460.86			.8	
411000	TRANSPORTATION TO INSTALLATION SITE	160.86		.0		
412000	INSTALLATION	4300.00		.8		
420000	TECHNICAL DATA MAINTENANCE	1353.16			.2	
430000	SUPPLY SUPPORT	47785.00			8.5	
431000	FSN MAINTENANCE	650.00		.1		
431100	PRIME SYSTEM	650.00	.1			
431200	SUPPORT EQUIPMENT	.00	.0			
432000	ACQUISITION OF REPLENISHMENT SPARES	47135.00		8.3		
440000	TRAINING	2690.77			.5	
441000	PAY AND ALLOWANCES (NAVY PERSONNEL)	881.88		.2		
441100	PROFESSIONAL COURSE	.00	.0			
441200	OPERATING AND MAINTENANCE COURSE	881.88	.2			
442000	COURSE MATERIAL	984.47		.2		
442100	PROFESSIONAL COURSE	.00	.0			
442200	OPERATING AND MAINTENANCE COURSE	984.47	.2			
443000	COURSE FEE	824.41		.1		
443100	PROFESSIONAL COURSE	.00	.0			
443200	OPERATING AND MAINTENANCE COURSE	824.41	.1			
450000	ACQUISITION OF SUPPORT + TEST EQUIP	.00			.0	
460000	OPERATIONS	32529.50			5.8	
461000	PERSONNEL,PAY AND ALLOWANCES	22171.22		3.9		
462000	FACILITY SPACE	10358.28		1.8		
470000	MAINTENANCE	65002.20			11.5	
471000	LABOR	9323.34		1.7		
471100	ORGANIZATIONAL (REPLACE)	1227.56	.2			
471200	INTERMEDIATE (REPAIR)	491.03	.1			
471300	DEPOT	7604.75	1.3			
472000	REPAIR MATERIAL	44927.50		8.0		
472100	INTERMEDIATE	8985.50	1.6			

Figure 8. Output Reports Generated by 1B Program

where

$$NK = 1$$

$$NH = 4100$$

$$LSD = 0.5$$

$$RSL = 14.36$$

$$R(K) = 10$$

$$N(I) = 3*0,5,12,22,34,8*43,$$

which, when applied to the algorithm, yields

$$(4100)(0.5)(14.36) \div (10) = 2943.8 \ .$$

Then, the summation of costs for the 15 year life cycle are

$$N(I) \sum_{K=1}^{NK} (3)(0) + (5)(2943.8) + (12)(2943.8) + (22)(2943.8)$$

$$+ (34)(2943.8) + (344)(2943.8) = 1227.564K \ .$$

This is the value shown for CBS 471 100 in figure 8.

COMPUTER OUTPUT REPORTS

Figure 8 also provides an example of the output reports generated by the LCC 1B Computer Program. They are the (1) summary, (2) cost breakdown structure, (3) general funding, and (4) annual cost by category (see figures 9 through 12, respectively). The use of the reports can be demonstrated by selecting cost breakdown structure CBS 132 200 and tracing its impact through each of them. The CBS 132 300 is concerned with travel costs and its algorithm employs the following costs factors:

1. BEP(P) -- the one way transportation costs during the T&E phase,

2. NDP -- the number of government personnel involved in T&E, and

3. DTES(I) -- the annual allocation of development testing and evaluation.

For this example, the values will be

1. BEP(P) = 11* 5276.48363,

2. NDP = 11, and

3. DTES = 0, .1, .15, .5, .25, 10*0

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NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

SUMMARY

$** COSTS IN THOUSAND DOLLARS $$$ INFLATION= .0%,DISCOUNT= .0%,BASE YEAR= 1

COST CATEGORY	DEVELOPMENT	ACQUISITION	INITIAL	RECURRING	COST CATEGORY TOTAL
	COST ELEMENT				
PRIME CONTRACTOR	16000.00	.00	.00	.00	16000.00
% OF COST CATEGORY TOTAL	100.0	.0	.0	.0	100.0
% OF COST ELEMENT TOTAL	29.8	.0	.0	.0	2.8
OTHER CONTRACTOR	36516.00	.00	.00	.00	36516.00
% OF COST CATEGORY TOTAL	100.0	.0	.0	.0	100.0
% OF COST ELEMENT TOTAL	68.0	.0	.0	.0	6.5
TESTING	592.63	.00	.00	.00	592.63
% OF COST CATEGORY TOTAL	100.0	.0	.0	.0	100.0
% OF COST ELEMENT TOTAL	1.1	.0	.0	.0	.1
PRIME SYSTEM	.00	344000.00	.00	4460.86	348460.86
% OF COST CATEGORY TOTAL	.0	98.7	.0	1.3	100.0
% OF COST ELEMENT TOTAL	.0	100.0	.0	2.9	61.7
TRAINING	630.14	.00	11001.54	2690.77	14322.45
% OF COST CATEGORY TOTAL	4.4	.0	76.8	18.8	100.0
% OF COST ELEMENT TOTAL	1.2	.0	82.3	1.7	2.5
SUPPLY SUPPORT	.00	.00	150.00	47785.00	47935.00
% OF COST CATEGORY TOTAL	.0	.0	.3	99.7	100.0
% OF COST ELEMENT TOTAL	.0	.0	1.1	31.1	8.5
TECHNICAL DATA	.00	.00	2216.56	1353.16	3569.73
% OF COST CATEGORY TOTAL	.0	.0	62.1	37.9	100.0
% OF COST ELEMENT TOTAL	.0	.0	16.6	.9	.6
SUPPORT EQUIPMENT	.00	.00	.00	.00	.00
% OF COST CATEGORY TOTAL	.0	.0	.0	.0	100.0
% OF COST ELEMENT TOTAL	.0	.0	.0	.0	.0
OPERATION	.00	.00	.00	32529.50	32529.50
% OF COST CATEGORY TOTAL	.0	.0	.0	100.0	100.0
% OF COST ELEMENT TOTAL	.0	.0	.0	21.1	5.8
MAINTENANCE	.00	.00	.00	65002.20	65002.20
% OF COST CATEGORY TOTAL	.0	.0	.0	100.0	100.0
% OF COST ELEMENT TOTAL	.0	.0	.0	42.3	11.5
COST ELEMENT TOTAL	53738.77	344000.00	13368.10	153821.50	564928.36
% OF LIFE CYCLE COST	9.5	60.9	2.4	27.2	100.0

Figure 9. Summary Report

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NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

COST BREAKDOWN STRUCTURE REPORT

$$$ COSTS IN THOUSAND DOLLARS $$$ INFLATION= .0%,DISCOUNT= .0%,BASE YEAR= 1

COST BREAKDOWN STRUCTURE NUMBER	COST BREAKDOWN STRUCTURE ELEMENT	TOTAL ADJUSTED COST	<---PERCENTS OF TOTAL ADJUSTED COST---->	< FOR TOTAL LIFE CYCLE				>
000000	TOTAL LIFE CYCLE	564928.36						100.0
100000	DEVELOPMENT	53738.77					9.5	
110000	PRIME CONTRACTOR	16000.00				2.8		
120000	OTHER CONTRACTOR	36516.00				6.5		
130000	GOVERNMENT	1222.77				.2		
131000	TRAINING	630.14			.1			
131100	PAY AND ALLOWANCES	5.14		.0				
131110	MILITARY	5.14	.0					
131120	CIVILIAN	.00	.0					
131200	FACILITIES	625.00		.1				
132000	PROTOTYPE TESTING	592.63			.1			
132100	TEST SITE	406.62		.1				
132110	MODIFICATION	.00	.0					
132120	INSTALLATION OF PROTOTYPE SYSTEM	.00	.0					
132130	OPERATION OF TEST SITE	406.62	.1					
132140	RESTORATION	.00	.0					
132200	PAY AND ALLOWANCES	69.42		.0				
132210	MILITARY	25.71	.0					
132220	CIVILIAN	43.71	.0					
132300	TRAVEL	116.08		.0				
132400	TRANSPORTATION OF MATERIAL	.50		.0				
200000	ACQUISITION OF PRIME SYSTEMS	344000.00					60.9	
300000	INITIAL	13368.10					2.4	
310000	TECHNICAL DATA	2216.56				.4		
311000	ACQUISITION	.00			.0			
312000	REPRODUCTION AND DISTRIBUTION	2103.80			.4			
313000	FIRST YEAR MAINTENANCE	112.76			.0			
320000	TRAINING	11001.54				1.9		
321000	PAY AND ALLOWANCES	235.42			.0			
321100	PROFESSIONAL	53.78		.0				
321200	OPERATING AND MAINTENANCE	181.64		.0				
322000	TRAVEL	670.85			.1			
322100	PROFESSIONAL	62.89		.0				
322200	OPERATING AND MAINTENANCE	607.96		.1				
323000	CONTRACTOR SUPPORT	832.77			.1			
323100	PROFESSIONAL	78.07		.0				
323200	OPERATING AND MAINTENANCE	754.70		.1				

Figure 10. Cost Breakdown Structure

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ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

GENERAL FUNDING REPORT

INFLATION= .0%,DISCOUNT= .0%,BASE YEAR= 1

$$$ COSTS IN THOUSAND DOLLARS $$$

COST BREAKDOWN STRUCTURE NUMBER	COST BREAKDOWN STRUCTURE ELEMENT	<- - - - - - - - - - GENERAL TYPE OF FUNDING - - - - - - - - -> R&D	PRO-CUREMENT	CON-STRUCTION	O&M	MILITARY PERSONNEL	TOTAL
000000	TOTAL LIFE CYCLE	52676.	359827.	16218.	106577.	29631.	564928.
100000	DEVELOPMENT	52676.		0.	1032.	31.	53739.
110000	PRIME CONTRACTOR	16000.					16000.
120000	OTHER CONTRACTOR	36516.					36516.
130000	GOVERNMENT	36516.					36516.
131000	TRAINING	36516.					36516.
131100	PAY AND ALLOWANCES	36516.					36516.
131110	MILITARY					5.	5.
131120	CIVILIAN	0.					0.
131200	FACILITIES				625.		625.
132000	PROTOTYPE TESTING				625.		625.
132100	TEST SITE				625.		625.
132110	MODIFICATION			0.			0.
132120	INSTALLATION OF PROTOTYPE SYSTEM	0.					0.
132130	OPERATION OF TEST SITE				407.		407.
132140	RESTORATION			0.			0.
132200	PAY AND ALLOWANCES			0.			0.
132210	MILITARY					26.	26.
132220	CIVILIAN	44.					44.
132300	TRAVEL	116.					116.
132400	TRANSPORTATION OF MATERIAL				0.		0.
200000	ACQUISITION OF PRIME SYSTEMS		344000.				344000.
300000	INITIAL	0.	11366.		1212.	790.	13368.
310000	TECHNICAL DATA	0.	11366.		1212.	790.	13368.
311000	ACQUISITION	0.					0.
312000	REPRODUCTION AND DISTRIBUTION		2104.				2104.
313000	FIRST YEAR MAINTENANCE				113.		113.
320000	TRAINING				113.		113.
321000	PAY AND ALLOWANCES				113.		113.
321100	PROFESSIONAL				54.		54.
321200	OPERATING AND MAINTENANCE					182.	182.
322000	TRAVEL					182.	182.
322100	PROFESSIONAL				63.		63.
322200	OPERATING AND MAINTENANCE					608.	608.
323000	CONTRACTOR SUPPORT					608.	608.
323100	PROFESSIONAL				78.		78.
323200	OPERATING AND MAINTENANCE				755.		755.

Figure 11. General Funding

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NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

ANNUAL COST BY COST CATEGORY

$$$ COSTS IN THOUSAND DOLLARS $$$ INFLATION= .0%,*UNDISCOUNTED*,BASE YEAR= 1

< - - - - - - - - - - - - - - - COST CATEGORY - - - - - - - - - - - - - - - >

YEAR	PRIME CONTRACTOR	OTHER CONTRACTOR	TESTING	PRIME SYSTEM	TRAINING	SUPPLY SUPPORT	TECHNICAL DATA	SUPPORT EQUIPMENT	OPERATION	MAIN-TENANCE	TOTAL
BASE YEAR 1											
1	4000.	4512.	0.	0.	630.	0.	0.	0.	0.	0.	9142.
CUM.	4000.	4512.	0.	0.	630.	0.	0.	0.	0.	0.	9142.
2	4000.	4350.	59.	0.	0.	0.	0.	0.	0.	0.	8409.
CUM.	8000.	8862.	59.	0.	630.	0.	0.	0.	0.	0.	17551.
INITIAL YEAR 3											
3	4000.	4080.	89.	0.	11002.	200.	2217.	0.	0.	0.	21587.
CUM.	12000.	12942.	148.	0.	11632.	200.	2217.	0.	0.	0.	39138.
4	4000.	5356.	296.	40519.	0.	50.	113.	0.	266.	980.	51580.
CUM.	16000.	13298.	444.	40519.	11632.	250.	2329.	0.	266.	980.	90718.
5	0.	5332.	148.	56726.	245.	4335.	113.	0.	638.	2300.	69837.
CUM.	16000.	23630.	593.	97245.	11876.	4585.	2442.	0.	904.	3281.	160556.
6	0.	3092.	0.	81037.	245.	4335.	113.	0.	1170.	4133.	94124.
CUM.	16000.	26722.	593.	178282.	12121.	8921.	2555.	0.	2074.	7413.	254680.
7	0.	3264.	0.	97245.	245.	4335.	113.	0.	1808.	6182.	113191.
CUM.	16000.	29986.	593.	275527.	12366.	13255.	2668.	0.	3881.	13596.	367871.

Figure 12. Annual Cost by Category

and applied in

$$\sum_{I=1}^{Y} \text{DTES(I)} \sum_{P=1}^{NDP} * 2 * \text{BEP(P)}$$

yields, for Y=15 years,

$$\sum_{I=1}^{Y} 0,\ 0.1,\ 0.15,\ 0.24,\ 10*0\ ,\ \sum_{P=1}^{NDP} 11 * 5276.483 * 2\ .$$

This shows that costs are spread over the second, third, fourth, and fifth years and are summed to a maximum of 11 civilian employees involved in the T&E effort. The yearly costs for transportation are shown in table 2.

Table 2. Yearly Transportation Cost

Year	Allocation Factor	Cost
2	0.10	\$11,608.263
3	0.15	\$17,412.395
4	0.50	\$58.041.315
5	0.25	\$29,020.658
		Total \$116,082.631

These costs appear in the summary report (see figure 9) as part of the development and testing cost total, which is \$592.63K. This represents 1.1 percent of the total development costs (listed at the bottom of the column as \$58,738.77K*). This value, in turn, represents 9.5 percent of the total life cycle cost, which appears in the lower right-hand corner

The transportation costs appear in the cost breakdown structure report (see figure 10) under the general category of prototype testing, which is CBS 132 000. There are ten subcategories, each with its own computation. The CBS 132 300 appears with a value of 116.08. The general funding report (figure 11) shows CBS 132 300 as travel cost having a value of 116. The annual cost by category (figure 12) shows that by year five, the aggregrate total testing costs has reached \$593K, including the \$116K for transportation.

TYPICAL SENSITIVITY ANALYSIS

An important feature of the LCC model is the capability to inject a range of values for a given cost factor (while all other factors remain constant)

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*Values do not always precisely coincide because of rounding during computation.

and generate a set of total LCC factors. This allows determination of the cost factors having the greatest impact on the total LCC factors.

Figure 13 provides an example of how the sensitivity analysis may be used. A preliminary life cycle run is depicted in which the system mean time between failures (MTBF) for cost factor R was varied by a range of 50 percent. The results shown in figure 10 are plotted in figure 14 where it can be seen that, for this hypothetical case, the impact on costs is nonlinear and that the nonlinearity becomes significant beyond the range of 20 percent. It can also be seen that an engineering change proposal (ECP) that would increase system MTBF by 10 percent would not be cost-effective (if the price of the proposal were in the $5M area).

SUMMARY

The development of a life cycle cost model can be helpful to the acquisition manager in making decision concerning to support. It is possible to use LCC to justify decisions on the basis of cost-effectiveness, as long as it is understood that LCC is not a highly-accurate cost accounting system. Instead, it is a tool for evaluating the relative costs of various support options.

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LIFE CYCLE COST ANALYSIS
MOD 1-B

DATE 7/19/77
PAGE 9.002

NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY, NEW LONDON, CT. (RA44)

ANALYSIS IDENTIFICATION AN/BRD-7 DEPOT TEST STATION COST ANALYSIS REPORT SPONSOR-NAVALEX-PME-107

SENSITIVITY ANALYSIS

$$$ COSTS IN THOUSAND DOLLARS $$$ INFLATION= .0%,DISCOUNT= .0%,BASE YEAR= 1

SENSITIZED VARIABLE: R MEAN TIME BETWEEN FAILURES FOR ITEM K

SEN. NUM.	MULTIPLIER	DEVELOPMENT	ACQUISITION	INITIAL	RECURRING	TOTAL LIFE CYCLE
		COST ELEMENT				
BASE	1.00	53738.77	344000.00	13368.10	153821.50	564928.36
1	.50	53738.77(.00)	344000.00(.00)	13368.10(.00)	210734.21(37.00)	621841.08(10.07)
2	.60	53738.77(.00)	344000.00(.00)	13368.10(.00)	191763.31(24.67)	602870.17(6.72)
3	.70	53738.77(.00)	344000.00(.00)	13368.10(.00)	178212.66(15.86)	589319.53(4.32)
4	.80	53738.77(.00)	344000.00(.00)	13368.10(.00)	168049.68(9.25)	579156.54(2.52)
5	.90	53738.77(.00)	344000.00(.00)	13368.10(.00)	160145.13(4.11)	571252.00(1.12)
6	1.00	53738.77(.00)	344000.00(.00)	13368.10(.00)	153821.50(.00)	564928.36(.00)
7	1.10	53738.77(.00)	344000.00(.00)	13368.10(.00)	148647.62(-3.36)	559754.48(-.92)
8	1.20	53738.77(.00)	344000.00(.00)	13368.10(.00)	144336.05(-6.17)	555442.91(-1.68)
9	1.30	53738.77(.00)	344000.00(.00)	13368.10(.00)	140687.80(-8.54)	551794.66(-2.32)
10	1.40	53738.77(.00)	344000.00(.00)	13368.10(.00)	137560.72(-10.57)	548667.59(-2.88)
11	1.50	53738.77(.00)	344000.00(.00)	13368.10(.00)	134850.60(-12.33)	545957.46(-3.36)

MATRIX OF VALUES FOR THE ABOVE SENSITIVITY ANALYSIS

ARRAY INDEX	BASIC VALUE	SEN. NUM. 1	2	3	4	5	6	7	8	9	10	11
	MULTIPLIER	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40	1.50
1	.12+002	.50+001	.60+001	.70+001	.80+001	.90+001	.10+002	.11+002	.12+002	.13+002	.14+002	.15+002

% - PERCENT CHANGE FROM BASE VALUE

@FIN

Figure 13. Sensitivity Analysis Use

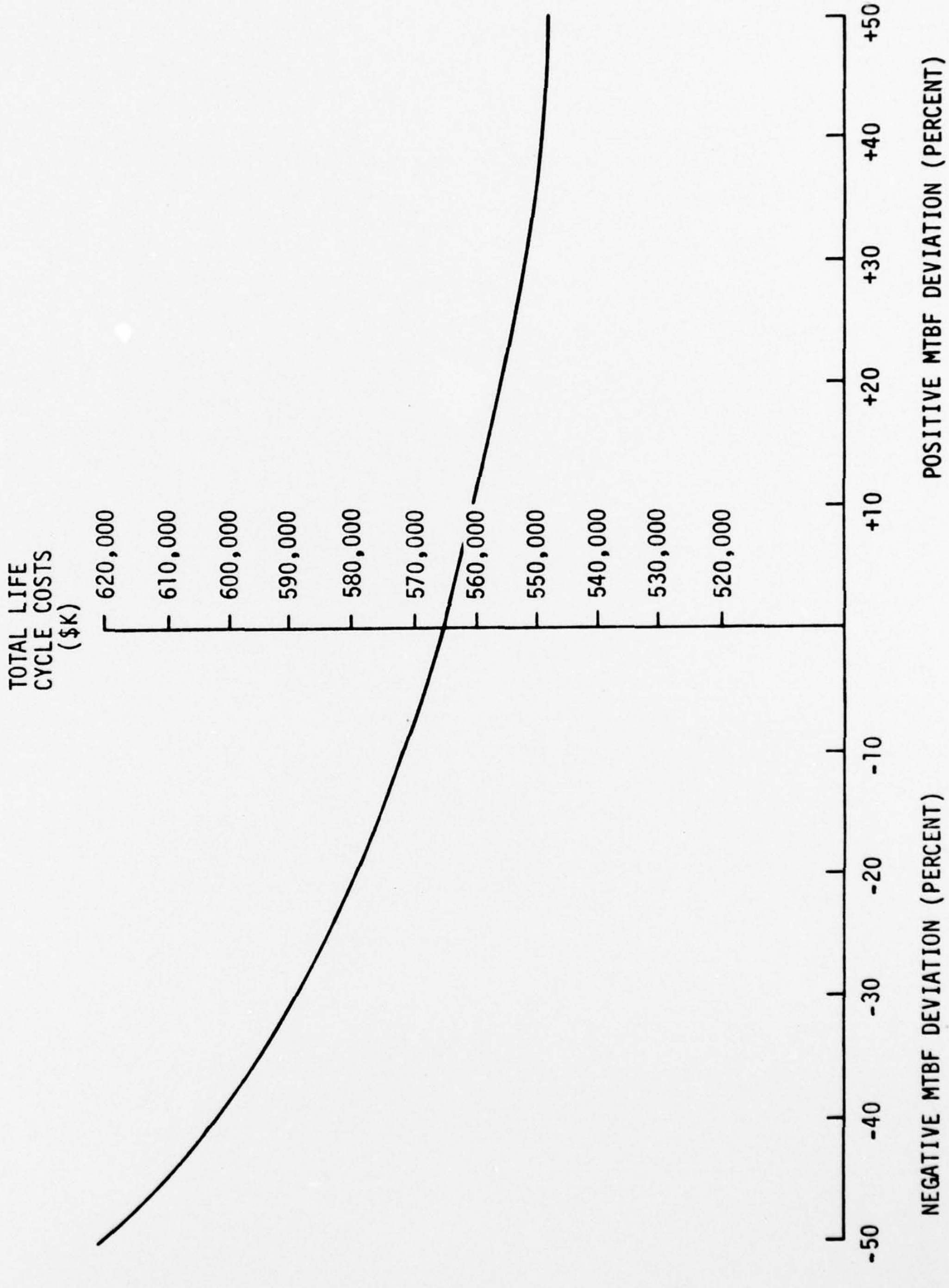

Figure 14. Cost Breakdown Plot

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Appendix A

COST FACTOR ANALYSIS REPORTS

LIFE CYCLE COST FACTOR - BTS (Units = $/man)

1. PROGRAM - SEA NYMPH PRIME

SEA NYMPH PRIME is identified as a Unit comprised of ten (10) Electronic Hardware Racks of equipment for which the BTS cost factor must be established.

2. DEFINITION - BTS

Student travel cost will be a round trip fare. The travel cost shall be provided for military and civilian (exempt and non-exempt) personnel.

3. SEA NYMPH APPLICATION - BTS

3.1 This application is based on data from the following sources.

3.1.1 Post EDM Planning Technical Report, Data Item D002, January 1977.

3.1.2 SEA NYMPH Navy Training Plan, NTP E20-7502, August 1976.

3.2 BTS Conditions Using Cost Factor "PTP"

The cost factor "PTP" will define the number of professionally skilled civilian maintenance personnel to receive initial training. The initial maintenance training courses will be held at GTE Sylvania, Mountain View, CA. The class size will be twelve (12) students and the training course duration will be twenty-four (24) weeks.

3.2.1 Origin and Destination Concerning Government Engineers and Senior Technicians (12)

Personnel	Origin	Destination
2 - PME-107	Washington, DC	San Jose, CA
4 - NUSC, NL	Groton, CT	San Jose, CA
6 - NESEC, SD	San Diego, CA	San Jose, CA

3.2.2 Car Rental (4) - For Professionals

This analysis will be based on three (3) persons per rental vehicle.

3.3 BTS Conditions Using Cost Factor "PTM"

3.3.1 The cost factor "PTM" will define the number of O&M skilled military maintenance personnel to receive initial training. The initial maintenance training courses will be held at GTE Sylvania, Mountain View, CA. The maintenance training course duration will be 24 weeks. The operator training course will be 12 weeks.

3.3.1.1 The number of military personnel attending the maintenance courses will be a total of thirty-six (36).

3.3.1.2 The number of military personnel attending the operator courses will be a total of eighty (80).

3.3.2 Origin and Destination Concerning Military Students for Maintenance and Operator's Training Courses

3.3.2.1 Military Personnel For Maintenance Training Course (36)

It is assumed that military personnel will come from the submarine operating bases in proportion to the number of SSN 637 platforms assigned.

Personnel	Origin	Destination
3 ET-1 4 ET-2	Norfolk, VA	San Jose, CA
2 ET-1 3 ET-2	Charleston, SC	San Jose, CA
6 ET-1 6 ET-2	Groton, CT	San Jose, CA
3 ET-1 4 ET-2	Pearl Harbor	San Jose, CA
2 ET-1 3 ET-2	San Diego, CA	San Jose, CA

Grade	Estimated Service Time
ET-1	> 6 years
ET-2	> 4 years

3.3.2.2 Car Rentals for Maintenance Courses (6)

This analysis will be based on six (6) persons per rental vehicle or 6 vehicles during the matintenance training courses.

3.3.2.3 Military for Operator's Training Courses

It is assumed that the operators will come from the SSN 637 platforms and the Navy Security Group detachments.

Personnel	Origin	Destination
4 ET-2 4 ET-3	Norfolk, VA	San Jose, CA
4 ET-2 4 ET-3	Charleston, SC	San Jose, CA
16 ET-2 16 ET-3	Groton, CT	San Jose, CA
12 ET-2 12 ET-3	Pearl Harbor	San Jose, CA
4 ET-2 4 ET-3	San Diego, CA	San Jose, CA

Grade	Estimated Service Time
ET-2	> 2 years
ET-3	> 3 years

3.3.2.4 Car Rentals (14) - For Operators

This analysis will be based on six (6) persons per rental vehicle or 14 vehicles rented during the operator courses.

3.4 SEA NYMPH PRIME Hardware Maintenance Qualifications

3.4.1 It is assumed that a military person must have at least four to six years of enlistment with the appropriate Naval technical training to be considered for SEA NYMPH PRIME hardware maintenance.

4. DATA REQUIREMENTS - BTS

4.1 The necessary data required to calculate the cost factor "BTS" using PTP and PTM are as follows:

4.1.1 Air Travel - Round Trip

Origin	Destination	Fare
Washington, DC	San Jose, CA	$392.00
Groton, CT	San Jose, CA	$452.00
Norfolk, VA	San Jose, CA	$414.00
Charleston, SC	San Jose, CA	$398.00
San Diego, CA	San Jose, CA	$118.00
Pearl Harbor	San Jose, CA	$280.00

4.1.2 Car Rental - Hertz Corporation

The car rental is based on an economy vehicle, class C at a monthly rate of $448.00 which is $14.93 per day for 30 days.

4.1.3 Subsistence

Subsistence for military personnel will be $41.00 per day (per diem) and for civilian personnel will be $41.00 maximum.

5. CALCULATION - BTS

5.1 BTS Using PTP (Professional Maintenance)

5.1.1 Air Fare - Round Trip - Civilian

From	To	Fare	Tickets	Total
Washington, DC	San Jose, CA	$392.00	2	$784.00
Groton, CT	San Jose, CA	$452.00	4	$1,808.00
San Diego, CA	San Jose, CA	$118.00	6	$708.00
			Grand Total	$3,300.00

5.1.2 Car Rental - San Jose, CA (24 weeks)

Vehicle/Month	No. Months	No. Cars	
($448.00)	(6)	(4)	= $10,752

5.1.3 Subsistence

Personnel	Allowance	No. Days	
(12)	(41.00)	(168)	= $82,656

5.1.4 Subtotals

Air Fares:	$3,300.00
Car Rental:	$10,752.00
Per Diem:	$82,656.00
Total (5.1)	$96,708.00

5.2 BTS Using PTM (Maintenance) (36)

5.2.1 Air Fare - Round Trip - Military

From	To	Fare	Tickets	Total
Norfolk, VA	San Jose, CA	$414.00	7	$2,898.00
Charleston, SC	San Jose, CA	$398.00	5	$1,990.00
Groton, CT	San Jose, CA	$452.00	12	$5,424.00
Hawaii	San Jose, CA	$280.00	7	$1,960.00
San Diego, CA	San Jose, CA	$118.00	5	$590.00
			Grand Total	$12,862.00

5.2.2 Car Rental - San Jose, CA (15 weeks)

Vehicle/Month	No. Months	No. Cars	
($448.00)	(3.75)	(6)	= $10,080.00

5.2.3 Subsistence

Personnel	Allowance	No. Days	
(36)	(41.00)	(105)	= $154,980.00

5.2.4 Subtotals

Air Fares:	$12,862.00
Car Rentals:	$10,080.00
Per Diem:	$154,980.00
Total (5.2)	$177,922.00

5.3 BTS Using PTM - Operators (80)

5.3.1 Air Fare - Round Trip - Military

From	To	Fare	Tickets	Total
Norfolk, VA	San Jose, CA	$414.00	8	$3,312.00
Charleston, SC	San Jose, CA	$398.00	8	$3,184.00
Groton, CT	San Jose, CA	$452.00	32	$14,464.00
Hawaii	San Jose, CA	$280.00	24	$6,720.00
San Diego, CA	San Jose, CA	$118.00	5	$590.00
			Grand Total	$28,270.00

5.3.2 Car Rental - San Jose, CA (15 weeks)

Vehicle/Month	No. Months	No. Cars	
($448.00)	(3.75)	(14)	= $23,520

5.3.3 Subsistence

Personnel	Allowance	No. Days	
(80)	(41.00)	(105)	= $344,480.00

5.3.4 Subtotals

Air Fares:	$28,270.00
Car Rentals:	$23,520.00
Per Diem:	$344,480.00

Total (5.3) $396,270.00

5.4 Summary - BTS Costs

The cost factor "BTS" is calculated in this report as the mean ($\overline{X}$) value for the sum of cost factors PTP and PTM.

5.4.1 BTS - Using PTP

For Professionals: $96,708.00

5.4.2 BTS - Using PTM

For Maintenance: $177,922.00

For Operator's: $396.270.00

5.4.3 Mean ($\overline{X}$) - BTS

For PTP + PTM

5.4.4 $\overline{X}_{BTS}$

$$\therefore \overline{X}_{BTS} = \frac{BTS_{PTP + PTM}}{\text{Total Students PTP + PTM}} = \frac{670,900}{128}$$

$$\overline{X}_{BTS} = \$5,241.00/\text{man}$$

Appendix B

LCC TRADEOFF ANALYSES

Number	Topic	Inputs Required
1	What would be the cost impact if a portable screener was placed at each IMA for Sea Nymph digital circuit cards (for Sea Nymph Prime)?	Number of Sea Nymph circuit cards considered to be screenable (LSA output).
		Number of good circuit cards being turned in for repair (AN/BRD-7 data from NESEC SD).
		Cost of screeners for each IMA (assume $25K).
		Cost of shipping good circuit cards to depot (SPCC).
		Cost of screening circuit cards at depot (NESEC SD).
		Cost of circuit card interface devices (NESEC SD).
		Cost of screening programs for circuit cards.
		Cost of training for IMAs to use screener.
2	What would be the cost impact of sparing each LRA on the submarine, in accordance with the modular repair concept as compared with a minimal set of resident spares for the E Suite with carry-on MCSE for deployments?	Cost of set of spare LRAs (provisioning list).
		Cost of a set of resident spares (LSA output).
		Cost of a set of MCSE for E Suite (LSA output).
		Number sets of MCSE to be procured (Navy ILS Plan).

Number	Topic	Inputs Required
3	What would be the cost impact if a portable screener was placed at each IMA and the IMA was allowed to make piece part repairs.	Number of Sea Nymph circuit cards considered to be screenable.
		Number of GFE circuit cards (BRD-7, UYK-20) that are considered to be screenable.
		Cost of screeners, training on screener use.
		Cost of documentation to cover piece part repair.
		Cost of circuit card interface devices.
		Cost of training to use screeners (a recurring cost).
		Cost of establishing tender load lists for piece parts.
		Cost of depot handling and repair.
		Cost of shipping circuit cards.
4	What are the long term cost impacts if the bulk of the technical manual is placed on microfilm or microfiche instead of printing it entirely on hard copy?	Cost of updating a printed page.
		Cost of updating a microfilm roll.
		Cost of updating microfiche cards.
		Cost of reader-printer if purchased for Radio Room.
		Cost of using BQQ-5 Reader Printer.

Number	Topic	Inputs Required
5	What would be the cost impact if the IMAs/ submarines were allowed to make selected piece-part repairs to analog modules, instead of always sending them to the Depot.	List of piece parts on each analog module that could be replaced at O/I level (LSA output).
		Cost of transporting analog modules to Depot.
		Cost of handling and repairs at Depot.
		Cost of establishing piece parts on tender.
		Cost of establishing piece parts on submarine.
		Cost of documentation for tender repairs.
		Cost of documentation for submarine repairs.
		Cost of training of O/I levels for repairs.
		Cost of equipment needed to make repairs.

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